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Abstract

This research tests the implicit assumption that cognitive development is independent of ethnic background. The testing instrument used was a newly designed spatial reasoning test intended to reflect the sequence of acquisition of skills requisite to map reading and drawing. A sample of 270 black, Chinese, and white subjects (90 each at the 5th, 7th, and 9th grade levels and of equivalent social class) were tested. The mean differences in map-reading ability between ethnic and age groups were significant. The data also support the proposition that each ethnic group has a unique fixed rate and sequence of cognitive development. Some support was evident for four secondary hypotheses: (1) positive correlation between map-reading scores (MS) and map drawing catagories (MC); (2) a significant increase in MS with grade level; (3) an increase in students' reasoning level as MC increased; and (4) an MS order of achievement for the three ethnic groups consistently occurring, (Chinese / white / black). A related document is EA 002 533. (LN)

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June 1969

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Abstract

The purpose of this study was to gather evidence bearing on the assumption of cognitive developmental theory that children, regardless of their ethnic background, proceed in their development toward abstract reasoning through the same stages although not necessarily at the same rate. Two hundred and seventy Black, Chinese, and White subjects, 90 each at fifth, seventh, and ninth grade levels, and of equivalent social class, were given a newly designed spatial reasoning test intended to reflect the sequence of acquisition of skills requisite to map-drawing. Developmental differences were inferred from means and patterns of item performance. The main hypotheses of the study predicted differences in mean levels of achievement, but no differences in the sequence of acquisition. Ethnic group was a significant source of variation in achievement ($F = 11.44$, $df = 2,261$, $p < .01$). To test the sequence of development, modified Guttman scaling techniques were employed. In their original order, the 25 items of the Map Test produced coefficients of reproducibility estimated to be .55, .64, and .58 for Chinese, Black, and White subjects, respectively. With the items reordered empirically according to difficulty, coefficients of reproducibility of .80, .82, and .81 were calculated for Chinese, Black, and White subjects. The agreement among the three reorderings of items was 43% (Hays, 1963, p. 656). Thus, each ethnic group's pattern of item performance approached Guttman scalability, but for a different ordering of the items. It was concluded that the ethnic groups did not differ in the extent to which their item performance exhibited a fixed sequence, but that the rate and the sequence of development for each group may be unique. The findings of the fixed-sequence

analysis did not agree with results reported by Kohlberg (1968) and Piaget (Inhelder, 1968). Several possible explanations were explored for the disparate results. The results of the study were interpreted cautiously due to the exploratory nature of the research, the crudeness of the measures, the large amount of variation in performance left unexplained, and the sensitive nature of the topic.

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THE FIXED-SEQUENCE HYPOTHESIS: ETHNIC DIFFERENCES IN THE DEVELOPMENT OF SPATIAL REASONING

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The Problem

Kohlberg (1968) wrote that an invariant sequence of stages of cognitive development is essential to the "cognitive-developmental" point of view. In calling for empirical data bearing on the question of invariant stages, he recommended that:

> "...it is extremely important to test whether a set of theoretical stages does meet the empirical criteria... If empirical sequence was not found, one would argue that the "stages" simply constituted alternative types of organization of varying complexity, each of which might develop independently of the other" (p. 1022).

Inhelder (1968), in a revision of her 1943 work on reasoning in the mentally retarded, also emphasized the importance of using objective statistical methods for assessing stages in reasoning development. Inhelder noted that results in the Genevan laboratory tend to indicate that development rates differ among subjects but that sequences of cognitive development are invariant:

> "In order to use statistics to determine whether the developmental succession of certain behaviors does follow such a hierarchical process, or whether it is simply a question of fortuitous temporal succession, it is necessary to resort to procedures of hierarchical analysis such as Guttman introduced into social psychology. We owe a debt to L. J. Cronbach for having suggested that we use ordinal methods as far back as 1954. Vinh Bang...found that the indices of reproducibility for the solutions furnished for various

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> tests are not the same for all ages. This is of great interest...because it promotes understanding of the dynamics inherent in the normal evolutionary process, in that it implies that the diverse types of operational behavior do not always follow the same speed of development..." (pp. 319-320).

Thus, two key aspects of the theory, as expressed by Inhelder, are that developmental rates may differ among subjects, but developmental sequences do not.

In one of the few empirical tests of the invariant sequence assumption, Wohlwill (1960) investigated the development of the number concept using techniques based on Guttman's (1947) scalogram analysis. A sequence of seven steps requisite to the number concept was hypothesized and supported. The coefficient of reproducibility and index of consistency, measures of the extent to which a set of items forms an adequate sequence, were .94 and .62 respectively; these values would generally be accepted as adequate evidence for an undimensional scale (Edwards, 1957).

In order for the invariant sequence assumption to be accepted, however, it must also be shown that it holds up despite differences in ethnic background among samples of subjects. But the number of cross-cultural studies of cognitive development has been small (Elkind, 1967; Bruner, Olver, & Greenfield, 1966; Skager & Broadbent, 1967), and there is some evidence that ethnicity may have a determining effect on the development of cognitive structures (Stodolsky & Lesser, 1967; Jensen, 1968; Bruner, Olver, & Greenfield, 1966; Whorf, 1956; Bernstein, 1962; Hess & Shipman, 1965). Thus it is crucial that the invariant sequence assumption be tested among groups varying in ethnicity.

Kohlberg (1968) cited one of his own studies on the development of dream concepts among American and Atayal children in support of the cog-

nitive-developmental position. In this study Kohlberg investigated the steps of development which are found in children's beliefs about dreams, and reported a Guttman scale coefficient of reproducibility of .96 for a six-stage sequence (N = 90).

The present study initiates a program of research aimed at further testing of the belief that sequences of cognitive development are independent of ethnic background despite differing rates of development. A test instrument, validated in a pilot study (Feldman, 1968), was designed to assess a hypothesized specific sequence of skills and concepts requisite to performance of a complex reasoning task. Ethnic differences were inferred from the pattern of item responses produced by the combined performance of members of each ethnic group:[2]

The experimental task used in the study was intended to assess the influence of ethnic background on acquisition of specific skills requisite to the proper drawing of a geographic map. Piaget and Inhelder (1967), among others, have shown that map drawing is an appropriate task for assessing the development of spatial reasoning. The modern map, a unique product of Western culture and an example of a scientific model, has also been shown to be difficult for non-Western children to understand (Salomon, 1968; Dart & Lal Pradham, 1967). Finally, Lesser and his colleagues (Lesser, Fifer, & Clark, 1965; Stodolsky & Lesser, 1967) found ethnic differences in spatial ability even when social class was controlled. Since social class has often been a confounding variable in studies which compare the performance of different ethnic groups (Stodolsky & Lesser, 1967;

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[2]Within the context of this study, ethnicity is assumed to be a combination of the unique cultural influences and the unique genetic endowment of a group.

Hess & Shipman, 1965; Eisner, 1967), the present study selected samples of equivalent socioeconomic level, but differing in ethnicity.

Hypotheses

Gagné's (1962) technique for analysis of hierarchical learning sets and a modified version of Guttman scaling were used to test the cognitive-developmental view hereafter referred to as the "fixed-sequence" hypothesis. The fixed-sequence hypothesis was separated into two parts, each of which was tested separately. First, it was hypothesized that with social class held constant there are differences in the level of achievement of three ethnic groups vis-à-vis the criterion task. Second, it was hypothesized that despite differences in the level of achievement exhibited by the ethnic groups, sequences of acquisition of concepts and skills would not significantly differ across ethnic groups.

In addition to the two parts of the fixed-sequence hypothesis, four secondary hypotheses regarding the validity of the experimental task were tested. These hypotheses are described in the results section.

A key assumption of the study was that developmental sequences of concept and skill acquisition are reflected in patterns of item performance and that rates of development are reflected in mean scores for each ethnic group.

Method

Subjects and Sampling Techniques

Subjects were 270 fifth-, seventh-, and ninth-grade students attending public schools in San Francisco, California. The difficulty in selecting schools with children of comparable social class but varying ethnic background was considerable, since social class and ethnicity tend to covary. Another difficulty, pointed out by Deutsch (1967), is that the same data may mean different things for different ethnic groups. An income of $6000 for a Black family may mean something quite different than the same income for a Chinese family. These difficulties notwithstanding, income and education level of parents were taken as indicators of social class (Hess, 1968). Table 1 presents the data for education and income of the populations of the schools selected for inclusion in the study.

Schools were chosen with relatively homogeneous ethnic populations at the elementary level; the junior high school chosen had about the same number of students from each of the three ethnic groups under investigation. Table 2 presents the ethnic mix of each of the schools selected.

The neighborhoods were described as lower-middle class by most informants; direct observation tended to support this description. It was recently estimated by the Chamber of Commerce that a $10,000 income is required for a family of four to live comfortably in San Francisco.

Two additional procedures were used in the present study. Principals were advised to exclude children from the testing sample who were from "upper-middle class" or from "severely disadvantaged" homes. They were also told to select students from all ability levels and behavior patterns, including "retarded" or "disruptive" students. Since students

TABLE 1

Median Income and Years of Education of Families

	Median Income	Median Education	Sample	Population
Elementary School B	$6300.00	12.1 Years	30	459
Elementary School C	$7000.00	12.4 Years	30	684
Elementary School W	$7000.00	11.9 Years	30	303
Junior High School	$6700.00	12.2 Years	180	997
Total	$6900.00	12.2 Years	270	2443

TABLE 2

Ethnic Mix of the Schools Selected for Study

	%White	%Black	%Chinese	Other	Groups Tested
Elementary School B	14.8	74.1	4.1	7.0	Black
Elementary School C	4.0	0.4	94.3	1.3	Chinese
Elementary School W	71.3	2.0	1.3	25.4	White
Junior High School	40.7	28.6	17.2	13.5	All (B, C, W)

were "tracked" in the junior high school, approximately equal numbers of students were selected from each track.

Although not a random sample from a well-defined population, the subjects of the study probably represent a large segment of the population of many American urban areas. The study is not generalizable to disadvantaged students, since part of the current meaning of the term disadvantaged includes poverty.

As stated earlier, the present study attempted to control for social class while examining variation due to ethnic group. The lower-middle class sample finally selected proved to be the only social class group on which it was possible to match the three ethnic groups selected for investigation.

Instruments and Scoring

The experimental task (Map Test) had two parts. A map-drawing task, similar to one used by Dart and Lal Pradham (1967) in Nepal and Hawaii, asked Ss to draw a map of the school and the school grounds as seen from above. The instrument was also related to Eisner's (1967) task, in which Ss drew a picture of the school grounds and their friends, and to the Piagetian diagram-drawing task. The map-drawing task of the present study put greater conceptual demands on the Ss than previous drawing instruments used to assess cognitive development. Goodenough (1924) and Harris (1963) asked Ss to "draw-a-man," "draw-a-woman," or "draw-a-tree." Piaget and Inhelder (1967) and Salomon (1968) provided a visual model which the Ss were free to use in constructing their diagrams. Eisner (1967) asked children to "draw-a-picture" of the school grounds which required memory and visualization, but did not demand abstract representation. Since performance on this map-drawing task required Ss to draw a map

from above with no memory support, it was expected that performance might fall somewhat below that found in previous studies. The purpose of the map-drawing task was to provide a criterion against which to validate a 25-item map-reading test (described below).

A scoring system was developed for the map-drawing task which took its content from Piaget and Inhelder (1967) and its scoring procedures from Eisner (1967). Based on Piagetian stages of spatial reasoning in diagrammatic layout construction, a six-category rating scale was developed. Each S's map was rated independently by two trained judges (both of whom were graduate school level psychology majors). Judges were trained with written descriptions of the categories and with example maps produced by pilot study children (Feldman, 1968). Initial agreement in ratings between the judges was 50-60%. After four training sessions, inter-judge agreement reached a criterion of above 80%; the judges disagreed in 2% of the cases by more than one category. Following independent rating, the judges were brought together to discuss disparate ratings. Agreement on 97% of the drawings was achieved in this manner, comparable to results reported by Eisner (1967). The remaining 3% of the drawings were arbitrated by the author.

The second part of the experimental task was a map-reading test. On the basis of results from a pilot study (Table 3, Feldman, 1968), a set of 25 map-reading items was arranged in a hypothetical fixed sequence of acquisition. The formal characteristics of the hypothesized fixed sequence are equivalent to Gagné's (1962) "hierarchical learning sets," and were stated by Gagné as follows:

1. If a higher-level learning set (item) is passed (+), all related lower-level tasks must have been passed.

2. If one or more lower-level tasks have been failed (-), the related higher-level tasks must be failed.

3. If a higher-level task is passed (+), no related lower-level tasks must have been failed (-).

4. If a higher-level task has been failed (-), related lower-level tasks must have been passed.

In his studies of learning sets, Gagné was not attempting to infer developmental sequences from his data. It is the distinction between typical learning and typical developmental sequences that separates the present study from Gagné's work. The actual arrangement of the items in the test instrument was intended to form a 25-stage set of prerequisites to the criterion, i.e., to proper drawing of an abstract, formal map.

Following Salomon (1968), the present map-reading test used a fictional island as its visual stimulus. Ss answered questions based on information in the visual stimulus, a copy of which was given each of them, and in material provided in a prepackaged booklet. Each of the 25 items in the test was designed to reflect S's level of acquisition of a concept or skill hypothesized to be requisite to proper performance in map drawing. The content of the items was based on Salomon's task analysis of the map and Piaget and Inhelder's (1967) research on spatial reasoning (see Table 3).

Of the 25 items, 17 were multiple-choice questions with four alternatives and a blank space if S wished to write his own answer. Each alternative in the multiple choice items was designed to reflect one of four different "reasoning levels." Designing distractors to give information other than "correctness" was suggested in a paper by Guttman and Schlesinger (1967). This procedure allows for the differential scoring of Ss on the

basis of the types of wrong answers to which they are attracted. Questions were designed so that each one of the distractors tended to reflect (a) tautological or imaginary reasoning (preconceptual thought in Piaget's terms); (b) perceptual or associative reasoning (beginning of concrete operations); (c) concrete reasoning (logical but limited to information in the stimulus); or (d) formal reasoning (not necessarily based on information directly obtainable from the stimulus). The four reasoning levels were extrapolated from Piaget's theory of cognitive development (Piaget, 1950, 1952; Flavell, 1963; Hunt, 1961; Sullivan, 1967).

Three sample items of increasing difficulty (Salomon, 1968) are presented below:

Identification:

#7 What does the little drawing near the town of Koff tell you?
a. It tells me something nice about the people who live in Koff. (Imaginary.)
b. It tells me there is a cow near Koff. (Perceptual.)
c. It tells me there is a dairy near Koff. (Concrete.)
d. It tells me that Koff is a place where cows are raised for milk and butter. (Formal.)

Analysis:

#8 How would you find out how far it is from one side of the map to the other?
a. I would ask a man who lives on the island. (Imaginary.)
b. I would drive a car and look at the miles. (Concrete.)
c. I would have to see if the roads are good. (Perceptual.)
d. I would use a scale on the map. (Formal.)

Interpretation:

#21 Circle the words which tell you what you think the weather is like on this island most of the time. List the reasons why you think the weather is what you say.
Rainy (Formal); Icy (Imaginary); Cold (Perceptual); Hot (Formal);
Foreign (Imaginary); Sticky (Formal); Windy (Concrete-Perceptual); Dry (Imaginary or Perceptual);
Foggy (Concrete-Perceptual); Icky (Imaginary); Cool (Concrete-Perceptual); Snows (Perceptual or Imaginary);
Humid (Formal); Pretty (Perceptual); Dusty (Perceptual); Smoggy (Concrete-Perceptual); Nice (Perceptual).

TABLE 3

Concepts and Skills Assessed by Items in the Map Test

Concept or Skill	Item Number(s)
I. Identification of:	
Stimulus	1
Ikons	2, 3, 4
Signs and Symbols	5, 6, 7
II. Analysis of:	
Distance	8
Map Heights	9
Filled vs. Empty Space	10
Map Directions	11, 12
Personal and Map Heights	13
Personal Heights	14
Personal Directions	15
Comparative Directions	16
Knowledge of Latitude	17
Map Directions with Logic Problem	18
Personal Directions with Logic Problem	19
Symbol Understanding-Abstract	20
III. Interpretation based on:	
Inferences about Weather	21
Choice of Capital with No Visual Symbol	22
Two Smallest Towns	23
Location for Harbor	24
Complex Hypothesis; Fishing Village vs. Farming Town	25

Map-reading tests were first scored for the number of "correct" items, i.e., in a manner identical to a standard multiple-choice test. This score was referred to as the map-reading test score (MS), and only formal answers were considered correct. MS was used to compare achievement levels, and items answered formally were considered as passed in the fixed-sequence analysis.

A second score was obtained by computing a mean reasoning level (RL) exhibited on the map-reading test as follows: an imaginary/tautological answer was scored 1; a perceptual/associative answer, 2; a concrete answer, 3; a formal answer, 4. All 25 items were evaluated in this manner and a reasoning level score was computed by the formula:

$$RL = \frac{\text{(Imaginary responses x 1) + (Perceptual x 2) + (Concrete x 3) + (Formal x 4)}}{\text{25 (Number of Items)}}$$

Reasoning level and map-reading test score are related since in general the RL increases as the number of items answered correctly increases. However, two subjects with identical map-reading test scores may exhibit markedly different reasoning levels, depending on the level of reasoning exhibited in the answers they "missed," as in the following hypothetical example:

S1

Total Score = 10
Formal: 10 x 4 - 40
Concrete: 15 x 3 = 45
Reasoning Level = 90/25 = 3.6 (Formal)

S2

Total Score = 10
Formal: 10 x 4 = 40
Imaginary: 15 x 1 = 15
Reasoning Level = 55/25 = 2.2 (Perceptual)

The reasoning level score was used to test the strength of the relationship between map-drawing categories and Piagetian stages of cognitive development.

Procedures for Administration

A primary purpose of the testing procedure was to reduce, insofar as possible within practical constraints, the dependence of a child's performance on his ability to read. Another purpose was to reduce the anxiety of test-taking to a minimum so that each child has the best possible opportunity to exhibit his reasoning about spatial concepts. The examiner (E) read all directions, each question, and its distractors aloud, proceeding as slowly as was necessary to insure each child the opportunity to think about and complete the items. Second, each examiner was of the same ethnic background as the children with whom she worked. Examiners of the same ethnic background as Ss were used by Lesser, Fifer, and Clark (1965) and Stodolsky and Lesser (1967) for similar purposes.

Ss were tested in groups of 15 in library, cafeteria, auditorium or classroom facilities. Procedures for getting the children out of class and into testing rooms varied from school to school and may have contributed to uncontrolled variations in the testing situation.

As the children entered the testing room, the following instructions were given by E:

> Good morning (afternoon). My name is Mrs._____.
> This morning (afternoon) you and I are going to do a map exercise together. In this exercise, we will be interested in how you draw and how you think about maps. Now I will give each of you a booklet which has some blanks for you to fill in on the front. (E distributed map tests.)
>
> Please fill in each of the blanks; circle if you are a boy or a girl. Now in the blank where it says "age," write your birth date, both the month and the year you were born.
>
> Now we will read the instructions, you to yourself and me out loud. (Instructions were read, making sure everybody understood that the drawing was to be of the school and the school grounds as seen from above.)

On the next page, which is a blank page, draw a map of the school and the school grounds as seen from above. You will have ten minutes to draw your map. Then wait for your next set of instructions. Good Luck!

O, K., finish up your drawings and we will go on to the rest of the exercise. Please don't turn the page until I ask you to do so. Now I am going to give each of you one of these (holds up stimulus map). For the rest of the work we will use these. Does everyone have one? (E kept a map for herself to point out what a question was referring to. For example, when E read the question having to do with the green color, she pointed to the green parts of the map.)

What we're going to do is not a test; it is an exercise to find out what you think are the best answers to some questions about maps. There will be no grades given; this is because we want to know your answers. You will have as much time as you need to do each question. If I go too fast, raise your hand, and we will wait. Remember, we are not interested in how fast you can go. I will read each question out loud as you read it to yourself. If you have trouble understanding the question the first time I read it, raise your hand, and I will repeat the question. Does everyone understand?

Is everyone ready? O. K., let's flip over the page and look at question #1. Notice that there are four possible answers and a space for you to write in your answer if you do not find one which you think is best. (Repeated for each question.)

Testing was done in the morning and early afternoon hours. All groups were tested within ten days of each other (October 7 through 17). Testing time varied from about one hour with fifth graders to about 45 minutes with ninth-grade children. Examiners reported that in general the children at all three grade levels appeared well motivated to complete the task and did not find it too easy or too difficult.

Results

Secondary Hypotheses

Results bearing on the four secondary hypotheses of the study were intended to assess the validity of the two parts of the Map Test. These results are presented first because confidence in interpreting the fixed-sequence analysis depends upon adequate validation of the test instruments.

Secondary hypothesis 1 predicted a significant, positive correlation between map-reading scores (MS) and map-drawing categories (MC). If the map-reading test assesses the skills and concepts requisite to proper map-drawing behavior, a significant agreement between the two measures was expected. The correlation between MC and MS was found to be .53 ($p < .01$) for the entire sample; subgroup correlations did not significantly differ from the sample. Although in support of the hypothesis, the agreement between the two instruments accounted for only 25% of the variation in performance. The restricted variability in MC (six categories) may have affected the MC x MS correlation, but on the basis of the present results, only modest support for the hypothesis was provided.

Secondary hypothesis 2 predicted significant increases in MS with grade level. Since inferences about development were being made from the data, it was crucial that performance levels increase with grade level.

Table 4 presents the means and standard deviations for each ethnic group at each grade level. Table 5 presents the results of an analysis of variance testing the effects of grade level on MS performance. The data show orderly increases in MS performance with each grade level and within each ethnic group (there were no sex differences in MS). Grade level had a significant effect ($p < .001$) on MS performance according to the analysis of variance.

TABLE 4

Means, Standard Deviations, and F Tests for Differences Between Ethnic Groups in Map-Reading Test Performance[1]

Ethnic Group	5th		7th		9th		All Grades	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Black	7.10	2.90	7.60	2.78	8.83	3.21	7.84	3.08
White	8.86	3.22	10.30	3.42	11.70	3.28	10.28	3.51
Chinese	9.50	2.90	11.20	3.70	12.03	3.72	10.91	3.63
Total	8.49	3.20	9.70	3.68	10.84	3.71	9.68	3.65

[1]Planned comparisons after an analysis of variance (Winer, 1963, pp. 65-70) produced the following results: Chinese vs. White Ss, F = 0.61, df = 1,87, p = NS; Chinese vs. Black Ss, F = 12.93, df = 1,87, p = <.01; White vs. Black Ss, F = 7.91, df = 1,87, p <.01.

TABLE 5

Analysis of Variance Testing Effects of Grade Level, and Ethnic Group On Map-Reading Test Scores (N = 270, 30/cell)

Source	Sum of Squares	df	Mean Square	F	P
Grade	249.76	2	124.88	11.44	<.001
Ethnic Group	471.80	2	235.90	21.62	<.001
Interaction	15.64	4	3.91	<1.00	NS
Within	2847.74	261	10.91		
Total	3854.93	269			

Hypothesis 3 predicted that reasoning level (RL) would increase as MC increased. This hypothesis was intended to relate the Map Test's reasoning measures to Piaget and Inhelder's (1967) stages of spatial reasoning (i.e., to MC). Since RL was intended to be a "deeper" measure of reasoning level than MS, and since Piaget claims that spatial reasoning is a special case of general reasoning development, RL and MC measures should be in substantial agreement.

Figure 1 shows the median RL of Ss whose maps were categorized in each map-drawing category. RL increased with MC up to category 6, at which point there was a decline in RL. However, out of 270 map protocols, there were only two placed in category 6 by the judges; the RL estimate for category 6 may therefore have been unreliable.

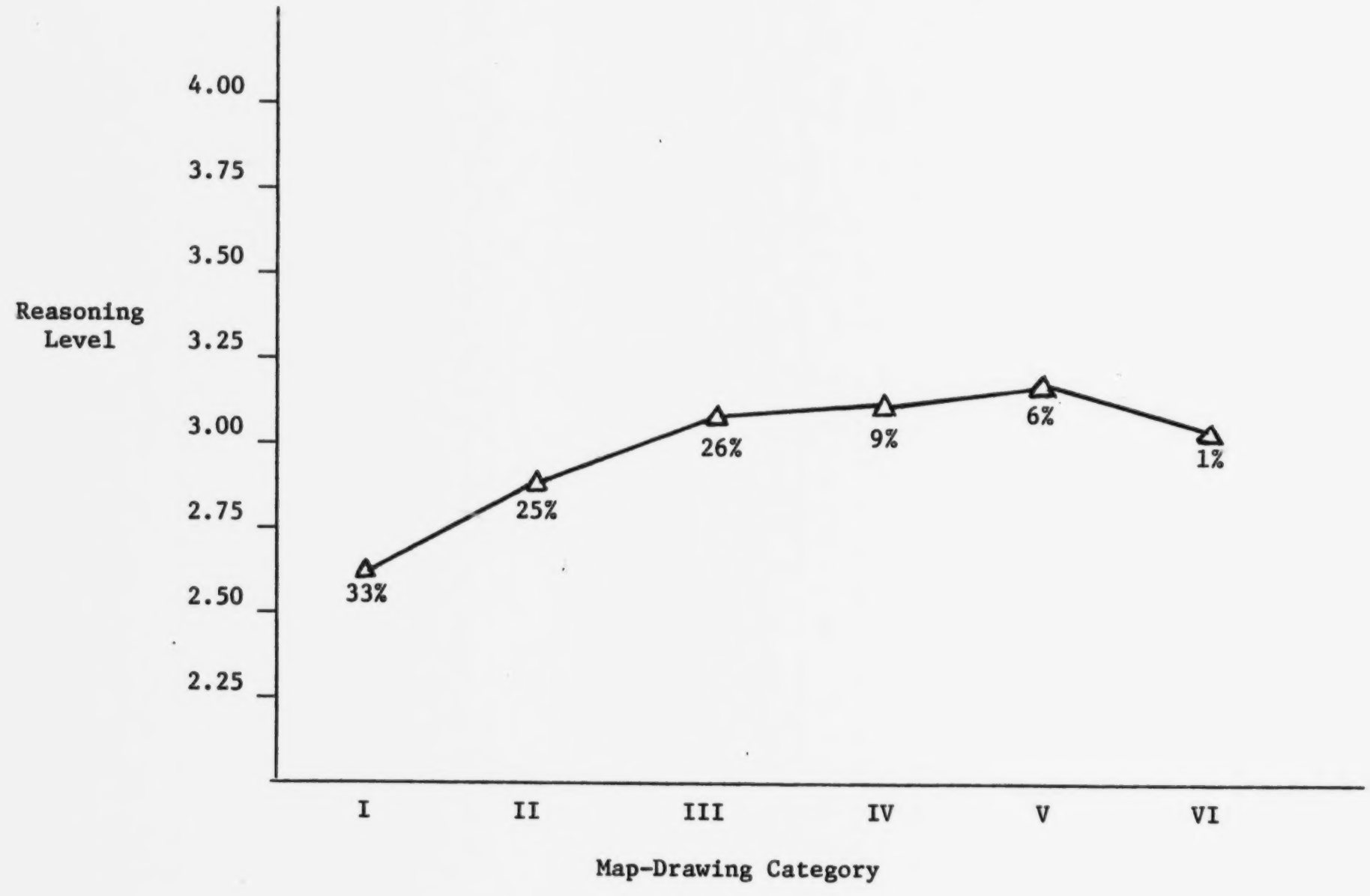
The hypothesis was generally supported by the data, but further research into the unpredicted results is called for.

Hypothesis 4 predicted that the order of MS achievement for the three ethnic groups would be: Chinese > White > Black. This prediction was based on Lesser's (1965, 1967) results indicating differences in spatial ability among children from various ethnic groups. The expected C > W > B relationship was found (Table 4), with C > B and W > B differences significant ($p < .01$); the C > W difference was not significant.

These results tended to support previous studies which have reported ethnic differences in mean levels of achievement on standard tests. The results also tend to support the validity of the map-reading test as a spatial reasoning measure, in that Lesser's findings were extended to the present sample of older children.

FIGURE 1

Mean Reasoning Level (RL) for Subjects Classified Into Each Map-Drawing Category



Fixed-Sequence Hypothesis

Part one of the fixed-sequence hypothesis predicted that ethnic group is a significant influence on MS achievement. This hypothesis followed from the vast literature on differences between means for Black and White Ss on standard tests of IQ and achievement (Jensen, 1968; Tyler, 1965), even when social class has been equated (Bruce, 1940; McQueen & Browning, 1960). Table 5 presents the results of the analysis of variance for ethnic group effects on MS performance. As shown in Table 5, ethnic group was a significant ($p < .01$) influence on MS. The mean differences in MS were taken to support the part of the fixed-sequence hypothesis which predicted differing rates of development for each ethnic group.

The fixed-sequence hypothesis also predicted (part two) that despite differences in mean levels of achievement on the map-reading items, all ethnic groups would exhibit a fixed sequence of item performance. Although there is little previous research on which to base the fixed-sequence hypothesis, the need for empirical data bearing on the notion of invariant sequences is crucial to testing the veracity of cognitive-development theory (Kohlberg, 1968; Inhelder, 1968; Pinard & Laurandeau, 1966).

Table 6 presents the results of scalogram analyses of the hypothetical fixed-sequence of item performance (part two). The first column of figures in Table 6 is based on the original ordering of the set of 25 items of the Map Test. The coefficients of reproducibility reported for the original ordering of the items do not approach an adequate Guttman scale for any of the ethnic groups tested; criterion is usually .85 to .90 (Guttman, 1947; Edwards, 1957). That is to say, the hypothetical ordering of the items did not scale as a fixed sequence for any of the three ethnic groups.

TABLE 6

Coefficients of Reproducibility for the 25 Items in the Map Test as Originally Ordered and as Reordered According to Their Pass/Fail Frequency in Each Group

	Original Order	Reordered	MMR[a]
Ethnic Group:			
Black	.64	.82	.74
Chinese	.55	.80	.70
White	.58	.81	.72

[a]The Minimal Marginal Reproducibility coefficient refers to the percentage of respondents in the model category. It sets the lower bound on the Coefficient of Reproducibility. It is important that many of the items divide about evenly between pass and fail so as not to have a spuriously high Coefficient of Reproducibility (Edwards, 1957). In the present study, the low mean scores for each group tended to inflate the MMR somewhat.

It should be noted that Guttman scaling techniques do not permit analysis based on an arbitrary or theoretical ordering of a set of items (Wohlwill, 1960). Part of the process of obtaining scalability estimates is an empirical reordering of items according to their difficulty. Therefore, the reported coefficients should be viewed as estimates of scalability. Estimates were produced by modifying Gagné's (1962) technique for analyzing hierarchical learning sets, i.e., doubling the number of errors that were computed according to Gagné's techniques.[3] Reproducibility estimates were produced for the original ordering of the 25 map-reading items for each ethnic group.

[3]The author is indebted to J. D. Elashoff of the Stanford Center for Research and Development in Teaching for suggesting this technique.

The second column of figures in Table 6 shows the coefficients of reproducibility for each ethnic group for the set of 25 items in the Map Test as reordered by the Cornell ranking technique, i.e., ranked according to difficulty with a formula for breaking ties (Edwards, 1957).

The results of the scalogram analysis with item sets reordered separately according to their difficulty within each ethnic group, indicated that the three ethnic groups did not differ in the extent to which their overall performance conformed to the fixed-sequence model. The results also indicated that all three groups' performance approached an adequate Guttman scale.

Discussion

Because of the way the fixed-sequence hypothesis was stated, the results could have been interpreted as supporting it. The prediction was that the three ethnic groups would not differ in the extent to which their item performance conformed to the fixed-sequence model. This condition was met by the data, but the items had to be reordered for the hypothesis to be supported.

Although not anticipated in the original analysis of the fixed-sequence hypothesis, it became of interest to assess the extent to which the reorderings of items differed for each ethnic group. Table 6 presents the items as reordered according to their difficulty for each group. A coefficient of concordance (W statistic) was computed among the three sets of items; the extent of agreement among the three sets was .59, or 43%, depending on the technique used (Hays, 1963, p. 656). No statement of

TABLE 7

Guttman Scale Program Reordering of the
Map Test Items According to their Difficulty
for Each Ethnic Group[a]

Item #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Black	8	1	6	11	4	10	5	7	20	19	13	17	24	9	15	2	18	16	22	3	12	14	23	21	25
Chinese	8	4	19	1	6	11	20	10	13	17	22	9	5	24	3	16	23	12	15	7	15	2	18	21	25
White	8	1	4	11	6	19	20	10	13	5	12	17	3	15	9	2	7	14	24	22	16	23	18	25	21

[a]Coefficient of concordance (Hays, 1963, p. 656) among the three sets of reordered items = 43%.

probability could be attached to the findings because of the small number of reordered sets (Hays, 1963, p. 656). However, it was clear that there was considerable variation in the reordering of the items among the three groups.

From these data it seemed possible that each ethnic group may exhibit a fixed sequence of item performance, but for a unique ordering of the set of 25 items. The implications of this unexpected finding are explored in the conclusions section.

Regression Analyses

To determine the power of the variables under investigation, a regression analysis was performed. The matrix of intercorrelations of the variables used in the regression analyses is shown in Table 8. These correlations provided the raw data from which prediction equations were calculated. The calculations were carried out by machine program (BMD02R).

The first analysis assessed the variance explained by the three independent variables of principal interest in the study: ethnic group, grade level, and sex. It was recognized that the stratified variables were neither ordinal nor interval scales, nor were they variable over a large range of values. Thus, the results of the analysis were viewed as preliminary estimates of the power of the variables, subject to further refinement and increased provision for variation in the measures. The results of the regression of ethnic group, grade level, and sex on map-reading test scores (MS) are presented in Table 9. Ethnic group accounted for the most variance (7.4%), grade level added about 7%, and sex 0%. The combination of these stratified variables yielded a multiple correlation of .38 with the criterion, thus accounting for about 14.5% of the total variation in MS.

TABLE 8

Intercorrelation Matrix of the Seven Variables of Major Interest in the Map Test Study (N=270)[a]

	MC	MS	RL	EG	GL	Sex	IQ
Map Category	....	.53**	.48**	.27**	.22**	-.22**	.39**
Map Reading Test Score		....	.89**	.27**	.26**	-.06	.53**
Reasoning Level			....	.26**	.30**	.01	.58**
Ethnic Group				....	.00	-.07	.22**
Grade Level					....	-.01	.23**
Sex						....	-.07
IQ							....

[a]Except in correlations involving IQ, where the N=199.

** p <.01

TABLE 9

Stepwise Multiple Regression of Ethnic Group, Grade Level, and Sex on Map-Reading Test Performance (N = 270)

Step	Variable	Multiple R	Increase in Variance	F
1	Ethnic Group	.27	7.4%	21.52**
2	Grade Level	.38	7.0%	21.72**
3	Sex	.38	0.0%	0.46

** p <.01

A second analysis was performed in order to determine the power of the combined variables on which data was collected. RL, which was taken from the same instrument as MS, was not included in the regression analysis. The results of this analysis are presented in Table 10. A multiple correlation of .65 was computed, with IQ and MC contributing almost equal shares of variance independently (28%), with their combined variance 38%. Grade Level was the only other variable which contributed significant variance after IQ and Map Category were taken out.

TABLE 10

Stepwise Multiple Regression of IQ, Map Category, Grade Level, Ethnic Group, and Sex on Map-Reading Test Scores

Step	Variable	Multiple R	Increase in Variance	F
1	IQ	.53	28.4%	78.23**
2	Map Category	.62	9.7%	30.70**
3	Grade Level	.64	3.4%	11.44**
4	Ethnic Group	.65	0.6%	2.01
5	Sex	.65	0.0%	0.17

** $p < .01$

The results of the regression analysis indicate that IQ and MC are the most powerful predictors of map-reading test (MS) performance. They also indicate that when IQ is removed from the total variance, ethnic group does not add a significant portion of explained variance. It should be noted, however, that ethnic group had only three values which were not intended to be ordinally related, although it could be argued that C >B >W mean MS

performance found in the three ethnic groups established such a relationship. It should also be noted that IQ and ethnic group are not independent. There was a greater likelihood of having a high IQ among Chinese Ss than Black Ss. This interaction between ethnic group and IQ makes it difficult to separate the two variables as if they were independent.

Limitations of the Data

The consistency in the data suggests that the results were not due to chance statistical significance alone; yet there are a number of reasons to view the results of the study cautiously. A review of the problems in its design and execution may help to place the results in perspective as well as to guide future research efforts toward sounder collection and analysis of data.

The most pervasive and general problem had to do with the nature of the stratified variable of ethnic group. Several contributors to the literature have questioned the typical physical characteristics of hair type, skin color, etc. as sufficient bases for the aspect of ethnic group having to do with racial classification (e.g., Tyler, 1965; Jensen, 1968; Cavalli-Sforza, 1969). Race as perceived by an observer and "subjective race" as perceived by an individual may vary considerably. For example, Milton (1957) found that sex-role identification was a better predictor of problem-solving performance than biological sex. Compounded with the difficulty discussed earlier in equating groups of subjects from different ethnic groups on social class, the ethnic group classification as well as the social class controls must be viewed as extremely crude. In order to overcome the difficulties in ethnic group classification, genetic markers have been suggested as better indicators (Cavalli-Sforza, 1969). Another possible approach is to classify children on the basis of

cognitive performance rather than physical characteristics; this approach has been suggested by Jensen (1968) and will be used in a study of concept formation by P. Engle of the Stanford Center for Research and Development in Teaching.

A second problem which had an undetermined influence on the results was that, because of lack of sufficient funds, subjects had to be tested in small groups rather than individually. As the Piagetians have demonstrated time and time again, much insight into process is gained in the individual testing situation. A number of items on the map-reading test could have been much more reliably scored if E had asked his subject why an answer was given. The dependence of performance on verbal and writing abilities would have similarly been reduced. The group-testing situation was also more likely to arouse anxiety in the children since it resembled a standardized testing experience.

Under these circumstances, the testing situation could have influenced children's motivation and feelings of security as they attempted to complete the task. Using examiners of the same ethnic group as the subjects was intended to reduce anxiety, but it was clear that many children felt threatened and nervous in taking the Map Test, especially Black children.

Another limitation on the findings of the present study is the lack of independence between map-reading test scores (MS) and reasoning level scores (RL), as described earlier. The purpose of the reasoning level measure was to attempt to relate findings vis à vis spatial reasoning to Piaget's statement regarding the unity of cognitive development. Piaget's descriptions of substages in cognitive development spanning the age range of the study Ss were guides to item construction. As a result, both MS and RL were based on the same instrument and were highly related. It is

impossible to conclude that spatial reasoning and general reasoning agree because it is impossible to separate the dependency relation from the independent influences underlying the scores. Studies should explore the usefulness of reasoning level estimates versus total scores in predicting school and test performance. For this purpose, reasoning level measures independent of specific task achievement are needed.

A further hindrance to clear interpretation of the results lies in the relatively low MS means for all groups of Ss. Since the map-reading items on the Map Test are supposed to represent a set of prerequisites to proper understanding of the spatial relationships in modern maps, the overall mean of 10 items correct out of 25 (Range = 1 to 18) suggests that most Ss are far from reaching criterion performance. Figure 1 indicates that the distribution of maps into the six categories was positively skewed, i.e., most Ss were not able to draw a proper geographic map of their school and schoolgrounds. Possibly the map-drawing task was too difficult; or perhaps upward revision of age estimates for criterion performance should be made. Just as likely, however, is the possibility that map-drawing and map-reading test performance in their present form are not valid indicators of spatial reasoning development. Post hoc inspection of the map-reading items has indicated a number of modifications should be made to improve the validity of the test.

In several instances, items could be answered correctly at both concrete and formal levels, but only a formal answer was counted as "correct." A reanalysis of the data counting selected concrete answers as correct is planned. Shifting the cut point between "correct" and "incorrect" responses would have two beneficial effects on the clarity of the results. First, the mean scores for all groups would be raised, eliminating some of the

problems in interpreting the map-reading items as a set of prerequisites to map-drawing performance. Second, by shifting the cut points to a more reasonable distinguishing point between correct and incorrect responses, Guttman scale coefficients will almost certainly go above .85 or .90, the usual criterion for an adequate Guttman scale.

In the present study an attempt was made to infer a single developmental sequence by testing children at three age levels. Since the level of performance increased as age increased, it was assumed that development took place with age. The process of development was assumed to be reflected in the pattern of responses made by the Ss and in the relationships predicted among various scores. Although by no means unique to the present study, problems in measuring development deserve greater attention.

Finally, future studies should attempt to increase the power of the variables by refining them, as well as to explore new variables (e.g., mental age, sex-role identification, other Piagetian tasks, more precise ethnic group and cognitive measures), some of which have already been discussed.

Conclusion

What light, if any, has the present study shed on the problem of invariant sequences of cognitive development? The results appear to contradict the cognitive-developmental assumption that children from all ethnic backgrounds develop skills and concepts in the same fixed sequence. The present study found that each ethnic group's performance was a fixed sequence, but that each such sequence was unique to a single group. Three "fixed sequences" were found where a single sequence was predicted.

There are a number of possible reasons why the results do not completely support the fixed-sequence hypothesis. It may be, for example, that the measures of reasoning development in the study were superficial and do not represent true developmental stages.[4] The skills requisite to map drawing may better reflect differences in learning histories and educational experiences than basic stages in cognitive development. There is inherent difficulty in the argument over whether or not a given set of measures of fixed sequences is basic enough. The argument can be carried on ad absurdum, with the critic at each turn accusing the investigator of being superficial, while the investigator accuses the critic of holding out until the data are consistent with his theoretical position.

The reasoning level measure taken in the study was based on Piagetian stages of cognitive development, i.e., the individual item responses in the Map Test were rated as either tautological/imaginary, preconceptual/perceptual, concrete, or formal. In analyzing differences between ethnic groups in reasoning level, as distinct from mean levels of map-reading test achievement, there was some evidence to indicate that RL differences remained constant as grade level increased, but that the differences in RL means were not great. Another suggestive finding was that Chinese Ss' RL was lower at Grade 9 than White Ss' (see Figure 1), despite their sustained higher mean level of MS performance.

The RL findings are for very small differences and should be viewed cautiously. It is possible, however, that the RL measure was tapping "basic" cognitive developmental stages, while item performance levels reflected the extent to which basic reasoning processes were applied to

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[4]I am indebted to R. D. Bridgham and L. J. Cronbach for their helpful comments on the interpretation of the fixed-sequence data.

concrete situations, perhaps an example of the "horizontal decalage" often referred to in writings about Piagetian stages.

Another way of looking at the fixed-sequence results would be to argue that some achievements are governed by a universal fixed sequence, while others are not. It is conceivable that the dream concept (Kohlberg, 1963) is developed through basically the same set of stages by all children, while proper map-drawing performance is subject to ethnic (and perhaps other) background influences.

Implications for Research and Practice

A number of implications of the present study should be investigated in future studies. Several of these implications have to do with the possible effects of order of item presentation on performance.

The set of 25 items in the map-reading test were administered in a fixed order. If fixed sequences of development exist, the order in which the items are presented should make no difference in the production of a fixed sequence or sequences. Future studies should randomize the items throughout the instrument to test this hypothesis. The initial ordering of items in the test did not yield a fixed sequence for any of the three ethnic groups tested in the study; it is possible that the order of presentation had disruptive effects of empirically derived fixed sequences such as those of the present research in facilitating or depressing performance of children from various ethnic groups.

If fixed sequences are shown to affect performance of children in systematic ways, then curriculum sequences may be made more sensitive to such influences as are found to exist. The assumption is implicitly made by curriculum planners and teachers as it is made by cognitive-developmental theorists that all children acquire reasoning skills in

the same sequence. Curriculums are constructed with this assumption built in. If the results of the present study are replicated and expanded to other areas of the curriculum, basic assumptions about curriculum construction may have to be revised.

Another possible implication of fixed-sequence research is in the area of IQ testing. Since IQ tests are generally constructed on the basis of item performance by members of a standardization group, IQ tests may not be allowing for systematic differences in developmental sequences among children from various backgrounds. In a typical IQ test situation, the session is terminated when a subject misses all items at a given level.

Studies are planned in which IQ test items are given in random order, and all subjects respond to all questions. Results will be analyzed in ways similar to those used in the fixed-sequence study reported here. It may turn out that children from differing backgrounds respond to item sequences in systematic but different ways. The notion of a culture-fair IQ test may take on new meaning in the light of these studies.

For the present, however, the results of the present study should be viewed with extreme caution due to the many problems in collecting the data, the crudeness of the measures, the large amount of variance in performance not explained, and the broad implications of the research vis à vis the small amount of research accumulated to date.

Summary

The purpose of this research was to gather evidence bearing on the assumption of cognitive developmental theory that children, regardless of their ethnic background, proceed in their development toward abstract reasoning through the same stages although not necessarily at the same rate.

A sample of 270 Black, Chinese, and White subjects, 90 each at fifth, seventh, and ninth grade and of equivalent social class, was given a newly designed spatial reasoning test intended to reflect the sequence of acquisition of skills requisite to map drawing. Testing was done in groups of 15 by female adults of the same ethnic background as the Ss. Each item was read aloud by the E, and Ss were assisted with reading and writing during the testing period. Developmental differences were inferred from means and patterns of item performance.

Results of the study were reported for two sets of hypotheses. The first set (secondary hypotheses) was intended to replicate the results found in a pilot study of validity of the map-reading test items as a measure of the skills requisite to map drawing (Feldman, 1968). It was found that map-reading test scores (MS) and map-drawing category (MC) ratings correlated .53 ($df = 268$, $p < .01$), providing moderate support for the hypothesis that the map-reading test measures skills requisite to map drawing and replicating earlier results. It was also found that MS correlated positively with IQ (except for Black Ss), which was not found in the pilot study, indicating that performance was at least partially influenced by IQ for these groups.

It was further predicted that the mean MS for Chinese Ss would exceed White Ss and that the mean MS for White Ss would exceed Black Ss. The predicted C > W > B relationship among means was supported by the data (C = 10.91, W = 10.28, B = 7.84). This finding tended to support Lesser's results on differences in spatial ability among specified ethnic groups (Lesser, Fifer, & Clark, 1965; Stodolsky & Lesser, 1967).

The main hypotheses of the study predicted mean differences between ethnic and age groups in map-reading performance (MS) but no differences

in the sequence of development. Ethnic group was a significant source of variation in MS ($F = 11.44$, $df = 2,261$, $p < .01$). To test the fixed sequence, modified Guttman scaling techniques were employed. In their original order, the 25 items of the map-reading test produced coefficients of reproducibility estimated to be .55, .64, and .58 for Chinese, Black, and White subjects, respectively, far short of an adequate scale. With the items reordered according to their difficulty for each ethnic group, coefficients of reproducibility of .80, .82, and .81 were calculated for Chinese, Black, and White subjects, values approaching criterion for a Guttman scale. The agreement among the three reorderings of items, however, was only 43% (Hays, 1963, p. 656).

Thus, each ethnic group's pattern of item performance approached Guttman scalability, but for a different ordering of the 25 items. It was concluded that the three ethnic groups did not differ in the extent to which their item performance exhibited a fixed sequence, but that the sequence of development for each group may be unique.

The findings of the fixed-sequence analysis did not agree with results reported by Kohlberg (1968) and Piaget (Inhelder, 1968). Several possible explanations were explored for the disparate results.

Multiple regression analyses showed that the variables of interest in the study accounted for about 38% of the variation in MS.

The results of the study were interpreted cautiously due to the exploratory nature of the research, the crudeness of the measures, the large amount of variation in performance left unexplained, and the sensitive nature of the topic.

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